MATERIALS PROCESSING

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INCREASING THE DIMENSIONAL STABILITY OF DIAMOND WHEELS FOR MACHINE GRINDING OF HIGH-QUALITY AND ART GLASS

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Higher productivity and lower costs of grinding articles made of high-quality and art glass are achieved by using special multispindle profiling machines or CNC machines. The dimension stability of diamond wheels for machine processing was increased by increasing the durability of the binder. It was established that adding 10% cobalt powder to the binder is optimal and results in 45 – 50% lower relative consumption of diamonds and 40 – 45% higher dimensional stability of wheels. New wheels for machine grinding of high-quality and art glass with 10% cobalt powder added to the binder are recommended for commercial use.

Key words: dimensional stability, diamond wheel, grinding, high-quality art glass, relative consumption of diamonds.

Special profiling and CNC machines are use to increase the productivity and decrease the cost of grinding articles made of high-quality and art glass in the world glass industry [1]. An advantage of such machines is that they make it possible to grind several glass articles simultaneously. Each article is ground by a separate grinding wheel. To increase grinding efficiency it is best to use diamond wheels with higher dimensional stability and increasing the time between the laborious re-grindings, which are necessary to restore the cutting capacity and to ensure the same wheel dimensions [1].

The present work is devoted to increasing the dimensional stability of diamond wheels for machine grinding of articles made of high-quality and art glass by increasing binder durability. The dimensional stability was characterized by the relative consumption of diamonds and the decrease of the diameter of a diamond wheel after grinding. The investigations were performed, by a method regulated by GOST 16181–82, on a V3-318E universal-sharpening machine with hydraulic longitudinal feed. In accordance with the recommendations presented in [1, 2] the grinding was performed with 1E1 wheels with dimensions $100 \times 6 \times 5 \times 90 \times 32$ with AS50 diamond powder with grain size 63/53 mm according to GOST 9206–80 without a coating on metallic binder consisting of metal and tin with hardness HRB105 – 110 and diamond powder concentration 100%.

Glass bars containing 24% PbO with dimensions $150 \times 100 \times 20$ mm were ground with speed v = 25 m/sec, feed rate S = 1000 mm/min, and grinding depth t = 1 mm using a water-based coolant. The grinding regimes corresponded to the grinding regimes when operating with eight spindle profiling machines made by the Petting Company. The grinding depth was monitored with a height-and-depth gage with scale division 0.1 mm.

The quality of the nickel coating was monitored visually with a BIOLAM microscope with magnification $\times 240$ and the free-fill bulk density with a volumeter [3].

The strength of the diamond grains was determined in accordance with the GOST 9206–80 on a DA-2M apparatus, which was developed at the Ultrahard Materials Institute at the Academy of Sciences of Ukraine [3]. For this, a diamond grain was placed between parallel corundum plates and subjected to uniaxial compression under an evenly increasing force. The apparatus automatically recorded the force when the grain fractured. To determine the average value, 100 grains were fractured.

The relative consumption of a diamond wheel was evaluated by a specially developed method. A thin steel plate was used for this; the plate was used to copy the profile of the

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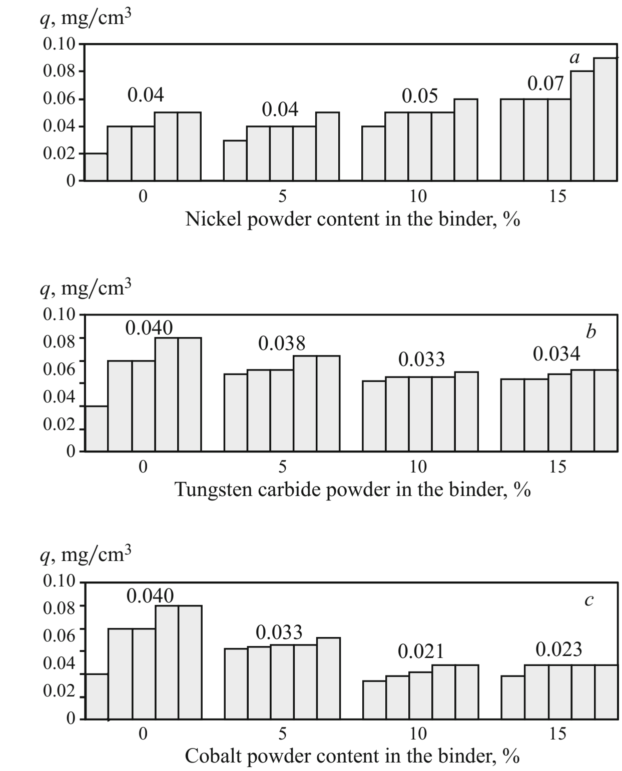

Fig. 1. Relative diamond consumption q (AS50 diamond powder) versus the content of nickel powder (a), tungsten carbide powder (b), and cobalt powder (c) in the binder on the wheel.

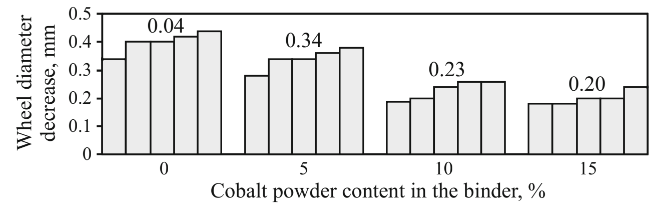

Fig. 2. Decrease of wheel diameter versus the cobalt powder content in the binder when using AS50 diamond powder.

wheel before and after grinding. Then a microscope with positional accuracy 0.01 mm was used to determine the profile coordinate of the plate. The decrease of the diameter of the wheel was evaluated according to the difference between the profile of sharp and blunted wheels. To calculate the average value of the decrease of the diameter of the diamond wheel after grinding, each measurement was repeated five times.

The quality of the worked surface was monitored with a Kalibr model 201 profilograph-profilometer in order that the optimization of the composition of the binder would not increase the roughness of the worked surface.

Nickel, tungsten carbide, and cobalt carbide were added in amounts 5 – 15% (of the total volume of the binder) separately to the binder of diamond wheels in order to increase the durability of the binder and increase the dimensional stability. As a result of the experiments, the dependences of the relative consumption of diamonds (AS50 diamond powder) on the content of nickel powder (Fig. 1*a*), tungsten carbide powder (Fig. 1*b*), and cobalt (Fig. 1*c*) were constructed.

It was found that adding to the binder nickel powder in amounts to 15% did not decrease the relative consumption of diamonds (Fig. 1*a*). It follows that the introduction of nickel powder into the binder will not increase the dimensional stability of diamond wheels for machine grinding.

Adding to the binder 5% tungsten carbide powder did not affect the relative consumption of diamonds (Fig. 1*b*). But adding up to 10% carbide powder to the binder decreased the relative diamond consumption by 15 – 20%. Increasing the amount of tungsten carbide powder to the binder to 15% did not decrease further the relative diamond consumption as compared with adding 10% tungsten carbide powder (Fig. 1*b*).

Adding 5% cobalt powder to the binder decreased the relative consumption of diamonds by 15 – 20% (Fig. 1*c*), while 10% decreased the relative diamond consumption by 45 – 50%. Increasing the amount of cobalt powder in the binder to 15% did not decrease the relative diamond consumption as compared with the addition of 10% cobalt powder. This means that adding 10% cobalt powder to copper and tin metal binder is optimal.

It was determined from the dependence of the decrease of the diameter of a diamond wheel on the cobalt powder content (to 15%) in the binder (Fig. 2) that for a 1% increase of the cobalt content in the binder the decrease of the wheel diameter as a result of wear slows down and, in consequence, the dimensional stability of the diamond wheel increases.

The roughness of the worked surface of the glass was measured by adding to the binder tungsten carbide and cobalt powder in amounts to 5 – 15%. The results showed that increasing the durability of the binder within the experimental limits did not appreciably affect the roughness of the worked surface, which varied in the range 1 – 1.1 μm.

Thus, our research showed that adding nickel powder to the binder used on wheels for machine grinding high-quality and art glass does not decrease the relative consumption of diamonds.

Adding the optimal amount of tungsten carbide (10%) to the binder decreases the relative diamond consumption by 15 – 20%, and adding the optimal amount of cobalt powder (10%) to the binder decreases the relative diamond consumption by 45 – 50% and increases the dimensional stability of the wheel by 40 – 45%.

Adding 10% tungsten carbide powder and cobalt powder to a metallic binder has no appreciably affect on the roughness of the worked surface, which is 1 – 1.1 μm with grain size of the diamond powder 63/53 μm.

As a result of these investigations, new wheels for machine grinding of high-quality and art glass with a binder to which 10% cobalt powder has been added were recommended for commercial use. The new wheels are now being used successfully in four large enterprises in Czechoslovakia and Slovakia.

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